"The Influence of a Magnetic Field on Radiation Frequency."

Communication from Professor OLIVER LODGE, F.R.S.

Received and read February 11, 1897.

I ask permission to bring before the notice of the Fellows a notable discovery recently made at Leyden by Dr. P. Zeeman, who is now elected Professor of Physics in the University of Amsterdam. To put myself in order, I will state that I have set up apparatus suitable for showing the effect, and have verified its primary feature, viz., that both lines in the ordinary spectrum of sodium are broadened when a magnetic field is concentrated upon the flame emitting the light.

Zeeman has observed it likewise with lithium, and with absorption as well as with emission spectra; taking precautions against deception by spurious effects due to changes of density or of temperature. It is thus probably not a chemical fact, dependent on the nature of a substance, but a physical fact, dependent on the nature of radiation and absorption, *i.e.*, a fact connected with the interchange of energy between ether and matter.

Faraday appears to have looked for some such phenomenon in the course of his latest magneto-optic researches in 1862, but he had not a Rowland concave grating at his disposal, and the effect is small.

I saw it with a 1-inch flat reflection grating containing 14,600 lines, and with an oxy-coal gas flame playing on pipe clay supporting carbonate of soda between pointed poles. I tried to see it by widening the slit till the D lines almost encroached on each other; thinking thereby to see the residual dark space obliterated by the magnetic action. A luminous haze seemed to spread over the dark chink when the magnet was excited, but the chink itself did not disappear; and the effect is more conspicuous and easier to observe when the narrowest slit possible is used, and when a micrometer spider-line is set down the middle of one of the D lines, of the second order spectrum, well defined in a field of considerable magnifying power.

The broadening is then unmistakable, and is symmetrical on each side; but I judge that the edges are not so bright as the central portion. The line appears brightened as well as broadened, *i.e.*, the previous borders of the line are brightened, and there are also gradated extensions. If the focussing is sharp enough to show a narrow, dark reversal line down the middle of either sodium line, that dark line completely disappears when the magnet is excited.

With the help of Professor H. A. Lorentz, the discoverer has initiated a simple theory of the effect, by considering the effect of

magnetic force on the motions of oscillating and revolving electrified particles possessing inertia (ions or electrons) in a magnetic field; and it is thus shown that the broadened edges of the line ought, on Lorentz's view, to be emitting polarised light, viz., plane polarised in directions normal to the lines of force, and circularly polarised in a direction along those lines.

This prediction has been experimentally verified by Zeeman, and has likewise been confirmed by myself. The flame being looked at from a direction perpendicular to the magnetic field, the light which will be dispersed by the grating to form the extended borders of a line is plane polarised, with its electric oscillations normal to the field's lines of force.

I hope to have the pleasure of communicating an English version of Professor Zeeman's complete paper to the March number of the 'Philosophical Magazine.'

"The Influence of a Magnetic Field on Radiation Frequency." Communication from Dr. J. Larmor, F.R.S. Received and read February 11, 1897.

In the course of the development of a dynamical hypothesis* I have been led to express the interaction between matter and ether as wholly arising from the permanent electrons associated with the matter; and reference was made to von Helmholtz (1893) and Lorentz (1895) as having followed up similar views. A footnote in Dr. Zeeman's paper has drawn my attention to an earlier memoir of Lorentz (1892), in which it was definitely laid down that the electric and optical influences of matter must be formulated by a modified Weberian theory, in which the moving electrons affect each other, not directly by action at a distance but mediately by transmission across the ether in accordance with the Faraday-Maxwell scheme of electric relations. The development of a physical scheme in which such action can be pictured as possible and real, not merely taken as an unavoidable assumption which must be accepted in spite of the paralogisms which it apparently involves,† was a main topic in the papers above mentioned.

The experiments of Dr. Zeeman verify deductions drawn by Lorentz from this view. It might, however, be argued that inasmuch as a magnetic field alters the index of refraction of circularly polarised light, which depends on the free periods of the material molecules, it must therefore, quite independently of special theory,

* 'Phil. Trans.,' 1894, A, pp. 719—822; 1895, A, pp. 695—743.

† H. A. Lorentz, "La Théorie Electromagnétique de Maxwell, et ses Applications aux Corps Mouvants," 'Archives Néerlandaises,' 1892. *Cf.* especially § 91.